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Population Trends of Three Congeners of Mole Salamanders (*Ambystoma*) at an Isolated Pond in Northeast Ohio

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Abstract: Long-term trends and Jolly-Seber estimates were used to study populations of the Spotted Salamander (*Ambystoma maculatum*), Marbled Salamander (*Ambystoma opacum*), and the Jefferson Salamander complex (*Ambystoma jeffersonianum*) at an isolated breeding pond in northeastern Ohio from 1993–2002. Population size of *A. jeffersonianum* complex declined significantly whereas that of *A. maculatum* declined but the decrease was not significant. The population of *A. opacum* fluctuated and exhibited no trend. Average annual adult survivorship was 73% for *A. maculatum* and 56% for both the *A. jeffersonianum* complex and *A. opacum*. Only 16 *A. maculatum* metamorphs were found during the nine year study compared to 56 *A. jeffersonianum* complex and 867 *A. opacum*. Declines were attributed to predation by *A. opacum* larvae and to insufficient hydroperiod. Toxic levels of copper may have contributed directly or indirectly to larval mortality.

Key Words: *Ambystoma*, drift-fence, amphibian decline, population estimation.

Introduction

Herpetologists have expressed concern over declines in many amphibian populations in the United States and elsewhere since the early 1980s (Mossman and Hine 1984; Blaustein and Wake 1990; Barinaga 1990; Stuart et al. 2004). Houlahan et al. (2000) reported that an analysis of nearly 250 data sets of North American amphibian populations showed that population sizes have declined at a rate of two percent annually since 1966. Call monitoring efforts (Mossman and Hine 1984; Moriarty 1996; Johnson 1998), population dynamics studies (Berven 1995; Pellet et al. 2006; Petranka et al. 2007) and temporal survey comparisons of anurans and caudates (Skelly et al. 1999) have provided valuable information regarding the distribution, abundance, and trends of many anuran species. Some long-term studies of salamanders monitored egg mass counts (Brodman 2002), larvae (Petranka et al. 2007) or drift-fence captured juveniles and adults (Gibbons and Semlitsch 1981; Pechmann et al. 1989). However, the local status of most salamander species remains largely unknown and few studies have applied mark/recapture population estimate models. Differentiating between fluctuations and declines of local amphibian populations is difficult and usually requires long-term study.

The number of reports and published papers concerning the effects of metals upon amphibians continues to grow (Freda 1991; Horne and Dunson 1994; Horne and Dunson 1995a, 1995b; Diana and Beasley 1998; Blaustein et al. 2003; Wind 2003). Metal toxicity to most species of amphibians and the toxicity relative to their various ontogenetic life stages have not been determined (Clark and LaZerte, 1987).

The purpose of our study was to investigate persistence stability of an *Ambystoma* community by examining trends and temporal changes in population sizes of the Spotted Salamander (*Ambystoma maculatum* Shaw), Marbled Salamander (*Ambystoma opacum* Gravenhorst), and the Jefferson Salamander complex, *Ambystoma jeffersonianum* (Green) at an isolated pond in a rural metropark. We also examined pH, hydroperiod, and metals as stressors potentially contributing to observed changes in population status. *A. maculatum* and *A. jeffersonianum* are common and widely distributed in Ohio whereas *A. opacum* is common and widespread in southern Ohio but rare and restricted to disjunct populations in the northeast portion of the state where the study took place (Seibert 1989; Pfingsten and Matson 2003). Naturally occurring communities including all three congeners and three ploidy levels of the *A. jeffersonianum* complex are rare in northeastern Ohio.

Methods

The study area was located in the Grand River drainage system of northeastern Ohio. It was within the 108 ha Indian Point Park, part of the Lake Metroparks system, and included an isolated seasonal pond positioned on a 9.2 ha floodplain terrace. The terrace supported a mature, species-rich, mixed floodplain forest community of nearly 20 arboreal species. Dominant tree species included: Tuliptree (*Liriodendron tulipfera* L.), American Elm (*Ulmus americana* L.), Sycamore (*Platanus occidentalis* L.) and Northern Red Oak (*Quercus rubra* L.). The most common understory shrub was Spicebush (*Lindera benzoin* L.). A variety of other spring ephemerals, including Virginia Bluebells (*Mertensia virginiana* L.), carpeted the forest floor around the pond (Bissell 1989). Surface area of the linear pond was 200 m^2; maximum depth was 59 cm (Quinn 2004). The canopy was nearly closed, and the pond did not support aquatic macrophytes, but algae, purple sulfur bacteria, fallen trees, siltstone slabs and accumulated leaf fall were present. Hydroperiod of the pond varied considerably from year to year; it never held water continuously through a calendar year. Although the pond was adjacent to Paine Creek, it did not receive floodwaters nor was it inhabited by ichthyofauna during our study.

The pond breeding amphibian community included: *A. maculatum*, *A. opacum*, and the *A. jeffersonianum* complex. *A. maculatum* bred in distant ponds within the park but barriers (wide streams, steep cliffs, etc) prevented exchange of individuals with those in the study pond population in all cases but one (Matson 1990a). Several *A. jeffersonianum* complex individuals were located within 1 km of the breeding pond, but they were on the opposite side of Paine Creek which we considered an effective isolating barrier. Additional occurrences of *A. opacum* within the Grand River drainage are known, but none occur within the park or within several kilometers of park boundries. Small breeding aggregations of Spring Peepers (*Pseudacris crucifer* Wied-Neuwied) were occasionally present in the spring but tadpoles were never located. Several other anurans, including Green Frogs (*Lithobates clamitans* (Latreille)) and American Toads (*Anaxyrus americanus* (Holrook)) were captured in the traps but never called while in the pond and no eggs or tadpoles were noted. Gray Treefrogs (*Hyla versicolor* LeConte) called from trees on the terrace but no evidence of breeding success was evident in the pond.

Ambystoma were captured entering and exiting the breeding pond using a drift fence and pitfall array similar to that described by Gibbons and Semlitsch (1981). This method is one of the most effective for conducting long-term population studies of pond breeding terrestrial species (Dodd and Scott 1994). Brown aluminum flashing 61 cm high was installed at a depth of ~13 cm along the rim of the pond depression. Twenty-two pitfall traps (18.9 L plastic buckets) spaced approximately 4.6 m distant were permanently positioned on each side of the fence (44 traps total).

Adult salamanders were marked by toe-clipping. Toe clipping is the most practical method for marking pond breeding salamanders and has no effect on growth or survival (Ott and Scott 1999). In 1993 a cohort mark was used; thereafter individuals were uniquely marked using a system similar to those of Martof (1953) and Twitty (1966). Four of the five toes on each rear foot were used in numbering; the fourth toe from the median was considered to have great importance in locomotion and was not clipped (Scott pers. communication). Levels of ploidy of individuals within the *A. jeffersonianum* complex included diploids, triploids, and tetraploids based upon erythrocyte size as described by Uzzell (1964) and methodology by Matson (1990b).

A rain gauge was used at the site to collect precipitation data on each visit. Pond water depth was also measured during each visit. pH was measured in the field during the a.m. over all seasons. An aliquot of pond water was collected for toxic metal study once at the end of the project; it was collected 10 cm below the surface in a plastic bottle containing nitric acid as preservative in April 2003. Cations tested included aluminum, copper, and total hardness. Chemical testing was conducted by BioSolutions Inc., an independent chemical laboratory.

Pond hydroperiod was calculated from the date at which standing water could be measured in the depression to the date at which no standing water remained in the pond, and it remained dry for an extended period. Spearman's Rank Correlation Coefficient was used to test for significance of the trend in annual pond hydroperiods and in pH samples from 1993–2000.

Annual adult population estimates were calculated using the Jolly-Seber model (Sutherland 1996) which was designed for the analysis of capture-recapture data obtained from open populations and which allows for variable survival rates. The model provides a relatively unbiased estimate of populations (Boulanger and Krebs 1994; Weinstein et al. 1995; Urban et al. 1999). Assumptions of the Jolly-Seber model are: (1) all individuals have equal probabilities of capture in a given year, (2) all marked individuals have the same probability of survival, (3) marks are not overlooked or lost and (4) sampling time is negligible compared to time between sampling periods (Krebs 1998). The most critical of these is the assumption of equal capture probabilities. We examined this assumption using Leslie's Test of Equal Catchability (Krebs 1998). Confidence intervals for population estimates were calculated using the method developed by Manly (1984) because the Jolly-Seber method has been shown to generate artificially small confidence interval estimates. Permutation tests using Spearman's Rank Correlation Coefficient were used to test for significance of population trends.

The method used to calculate annual adult survivorship was similar to that described by Husting (1965). The total number of all adults known to be alive in both year i and year i + 1 was divided by the total number of adults known to be alive in year i. Since it was important to know the capture history of individuals before and after year i and i + 1 respectively, estimates were only made for the years 1995-2000.

Results

During the months of February through May, the pond held standing water every day of each month throughout the 10 years of the study. The longest hydroperiod occurred in 1996 when the pond contained some standing water each month of the year. The shortest occurred in 2002 when the pond dried in early July and did not re-fill that year. During seven of the years, pond hydroperiod ended before August first. In the remaining two years, it extended into mid-August one year and to early September the other. Hydroperiod length declined significantly ($p = 0.02$) over the course of the study. Mean pH of the pond water was 7.0 ($n = 35$; range 6.4–7.9) and declined significantly ($p = 0.001$), but the decline was slight and not considered ecologically significant. Laboratory and in-situ studies have shown that breeding ponds with a pH above 5.5 do not negatively impact pre-metamorphic salamanders either through delayed growth or development or increased mortality (Pough 1976; Sadinski and Dunson 1992; Rowe and Dunson 1993; Petranka 1998).

Total concentrations (µg/L) of cations present in the April 2003 aliquot of pond water were as follows: Al (< 100), Cu (20), and total hardness (300,000). Aluminum concentrations were low and below our level of detection and similar to those found in ponds supporting amphibian populations in central Pennsylvania (Horne and Dunson 1995a) an in Virginia (Blem and Blem 1989, 1991). Copper on the other hand, although low in concentration, was higher than those reported in central Pennsylvaia where *A. jeffersonianum* suffered high mortality (Horne and Dunson 1995a, 1995b). The level was similar to those reported in Virginia contributing to high embryonic mortality in *A. maculatum* (Blem and Blem 1991). Seasonal ponds in eastern states characteristically have low total hardness (Horne and Dunson 1994). Total hardness in our pond was several orders of magnitude greater (hard water, USGS water hardness scale).

The null hypothesis of equal catchability was accepted for *A. opacum* and the *A. jeffersonianum* complex but not for *A. maculatum*. In long-term mark-recapture studies of species with long life spans, low recruitment, and little to no immigration, it is expected that a high percentage of individuals in the population will eventually be marked. Dispersal of juvenile and/or adult *A. maculatum* from the nearest pond ~350 m distant probably explains unequal catchability. Dispersal distances of 249 m for *A. maculatum* were reported by Kleeberger and Werner (1983), and Petranka et al. (2007) placed the average dispersal distance of eastern amphibians as < 1–2 km. Immigration was probable because only 16 metamorphs were recruited from the study pond while unmarked adults were captured each year, including the final years of the project. Immigration would result in an overestimation of population size.

The number of breeding *A. maculatum* captured annually declined 58% from a high of 182 in 1995 to 77 in 2001 and then rose slightly to 93 in 2002 (Figure 1). Sex ratios of breeding adults favored males approximately 2:1 in the early years of the study but shifted to 1:1 by 2002. Recruitment was limited, 16 larvae transformed from 1994–2002, a mean of 1.8 metamorphs annually (Table 1).

The breeding population of *A. jeffersonianum* complex decreased 88%, from 154 in 1994 to 19 in 2002 (Figure 1). The ratio of diploid individuals to polyploidy unisexuals and those of unknown ploidy captured each year was approximately 1:1 through 1999. In the last three years of study, the number of unisexuals and unknowns exceeded that of diploids nearly 2:1. The overall sex ratio of breeding adults was highly skewed toward females, attributable to the high numbers of polyploid unisexuals. In 1994 the ratio of males to females was 1:6.6; it declined to 1:11 by 2001. Only two males were captured in 2001 and one in 2002. From 1994–2002 56 metamorphs were found, a mean of 6.2 annually (Table 1); however, only one metamorph was recruited after 1998.

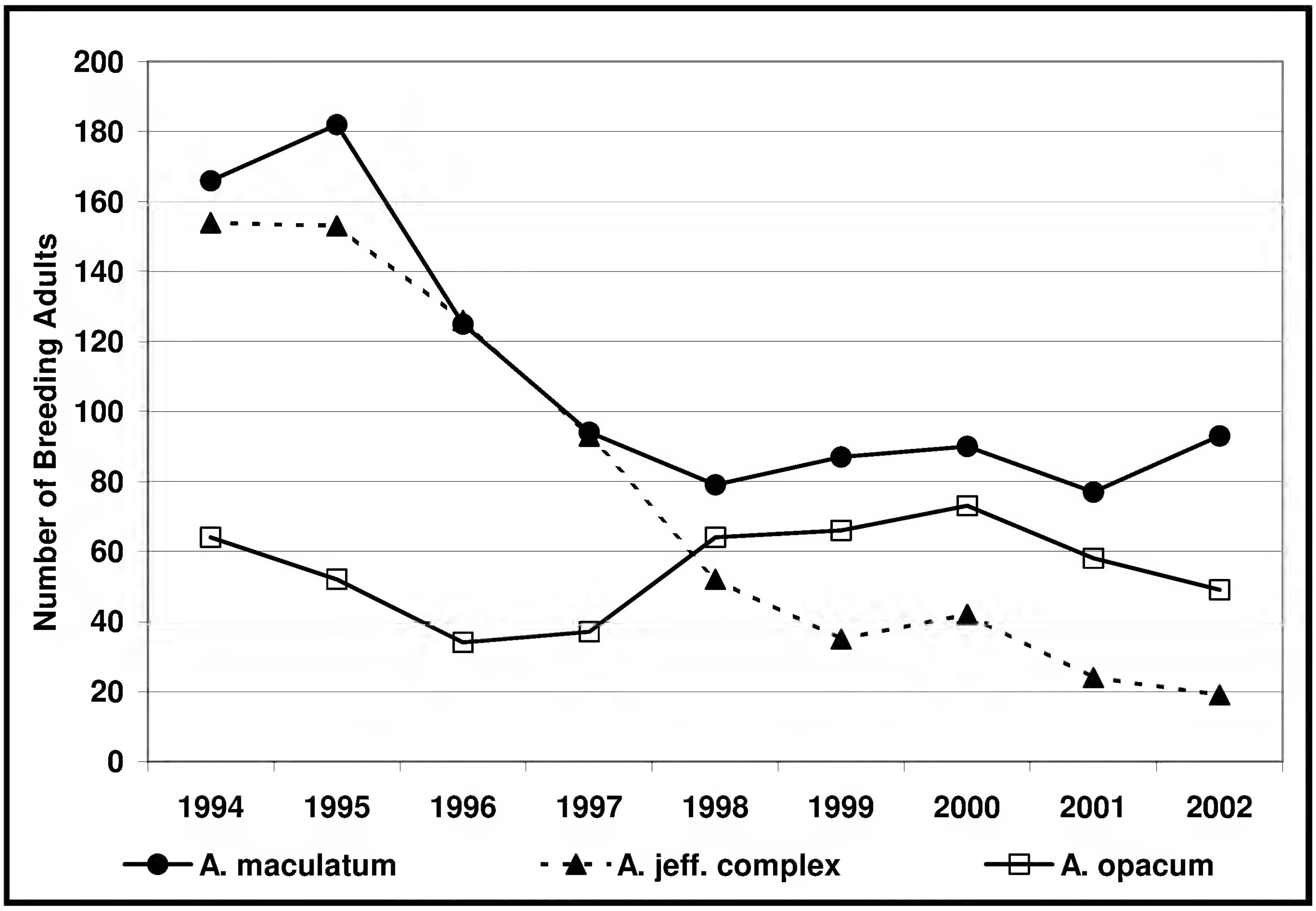

Figure 1. Number of adult salamanders of each taxon captured at the drift-fence moving toward the breeding pond from 1994–2002.

No trend was apparent in the annual breeding counts of *A. opacum* (Figure 1). Ratios of males to females varied from 1:1 to nearly 3:1, although in two years, females outnumbered males approximately 2:1. From 1994–2002, 867 juveniles were captured, a mean of 96.3 annually (Table 1). Mean annual adult survivorship for *A. maculatum* was 73% (range 66–81%) whereas that of both the *A. jeffersonianum* complex and *A. opacum* was 56% (ranges 49–66 % and 49–65%, respectively).

Table 1. Juvenile recruitment of taxa captured at the drift-fence moving outward from the breeding pond from 1994–2002.

Year	***A. maculatum***	***A. jeffersonianum* complex**	***A. opacum***
1994	4	4	99
1995	0	3	29
1996	2	1	237
1997	1	36	3
1998	7	11	22
1999	0	0	70
2000	2	1	150
2001	0	0	235
2002	0	0	22
Total	**16**	**56**	**867**

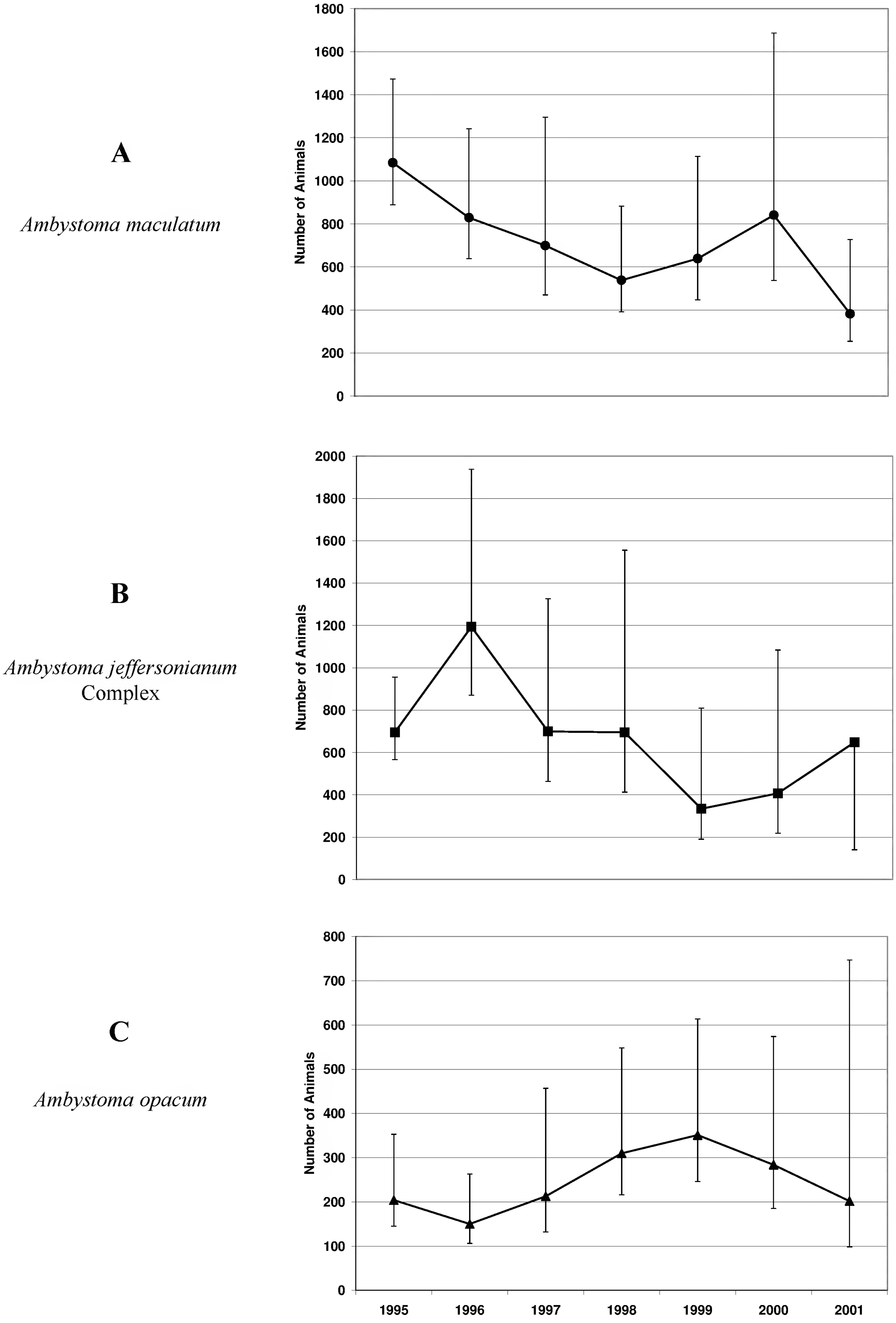

Figure 2. Annual Jolly-Seber population estimates of adult salamanders of each taxon captured at the drift-fence moving toward the breeding pond from 1995–2001. Error bars represent 95% confidence intervals. A. (upper) estimates for *Ambystoma maculatum*; B. estimates for the *A. jeffersonianum* complex; C. (lower) estimates for *A. opacum*.

Comparison of Jolly-Seber population estimates was consistent with count trends of breeding adults for all taxa (Figure 2). Annual population estimates for *A. maculatum* including unknown numbers of immigrating individuals indicate an insignificant decline from 1995–2001 ($p = 0.08$) whereas those for the *A. jeffersonianum* complex population indicate a significant temporal population decline ($p = 0.04$) over the seven year period. A number of researchers (Semlitsch and Brodie 1998; Lehtinen et al. 1999; Marsh and Trenham 2001) have emphasized the importance of metapopulation dynamics in preserving pond-breeding amphibians. Immigration at least partially explains the lack of significance between population estimates for *A. maculatum,* especially when considering the low reproductive recruitment. In contrast, annual population estimates for *A. opacum* varied above and below 1995 levels ($p = 0.56$) and appeared to exhibit the truncated curve of a species near carrying capacity (Smith and Smith 2001).

Discussion

Quantitative evidence indicates that substantial declines in the population size of the *A. jeffersonianum* complex and *A. maculatum* occurred. Predation by larval congeners and limited hydroperiod were probable causal factors with copper toxicity a probable contributing stressor. Annual survivorship indicates that about one-third of *A. maculatum* adults and nearly one half of the adult *A. jeffersonianum* complex died each year. Furthermore, little juvenile recruitment (*A. maculatum*) and no immigration (*A. jeffersonianum* complex) occurred to replace those losses.

There is no direct evidence that predation by larval congeners was a major factor in the decline of *A. jeffersonianum* complex and *A. maculatum* populations. However, *A. opacum* larvae have been cited as causing decreased survivorship of *A. jeffersonianum* larvae in experimental pens (Cortwright 1988), of newly hatched *A. jeffersonianum* larvae in a permanent pond (Williams 1973), and of both eggs and larvae of *A. jeffersonianum* (Walters 1975). Adult female *A. jeffersonianum* arrived at the breeding pond an average of 20 days earlier than those of *A. maculatum*; consequently, *A. jeffersonianum* eggs and larvae were potentially subjected to heavier predation by *A. opacum* than those of *A. maculatum* whose eggs were laid later and require longer developmental periods (Downs 1989; Nyman 1991; Brodman 1995).

High premetamorphic mortality of *A. maculatum* from *A. opacum* has been reported in ponds by Wilbur (1972), Williams (1973), Doty (1978) and Stenhouse (1985). In addition to predation by *A. opacum* larvae, *A. maculatum* larvae were also subject to predation by *A. jeffersonianum* larvae (Walters 1975). In experimental tanks, Walls and Williams (2001) showed that *A. jeffersonianum* larvae depress the biomass of *A. maculatum* by 47.9% and by 74.6% when in combination with *A. opacum*.

A. maculatum larvae surviving in ponds with *A. opacum* larvae have been reported by Doty (1978) and Cortwright (1988). However, mitigating factors including alternative prey, such as tadpoles of the Wood Frog, *Lithobates sylvaticus* (LeConte), and Cope's Gray Treefrog, *Hyla chrysoscelis* Cope, or the presence of suitable refugia were present, or periodic lengthy hydroperiods occurred (Stenhouse 1985; Petranka 1998). At our pond, no alternative anuran tadpole prey existed and hydroperiods were rarely optimal for *A. maculatum*.

Since the pond was nearly always dry by late August, it provided optimal conditions for egg laying and larval development of *A. opacum* which, in turn, would predictably increase predation on the two spring breeding congeners. The typical hydroperiod, which ended in early to mid-July, was too short to allow transformation of most *A. maculatum* larvae, but it was sufficiently long for transformation of some *A. jeffersonianum* complex larvae. The majority of *A. maculatum* metamorphs in ponds at similar latitude and climate to our pond disperse from mid-August through September (Shoop 1974; Wilson 1976; Downs 1989; Paton and Crouch 2002). In some nearby permanent, fishless ponds, metamorphs and gilled larvae can be found at least into mid-September (Matson, pers. observation). Recent metamorphs and some transforming larvae can survive in the wet pond substrate for a period of time after pond drying (Shoop 1974). Therefore, a hydroperiod continuing into at least the first weeks of August was required to allow even moderate *A. maculatum* recruitment, a hydroperiod that occurred twice during the 10 years. In contrast, most *A. jeffersonianum* metamorphs disperse in July and August suggesting that, with low predation, more than the documented 6.2 juveniles per year would be recruited. Some authors (Bishop 1941; Wacasey 1961; Williams 1973) though, report transformation occurring in late August or mid-September indicating that more *A. jeffersonianum* complex larvae may have transformed given a longer hydroperiod.

Copper was found to cause complete mortality in *A. jeffersonianum* larvae at a concentration of 15 µg/L in toxicity tests conducted at pH 4.5 and 5.5 (Horne and Dunson 1995b). The low recruitment and significant decline in population size of the *A. jeffersonianum* complex at our site ([Cu] = 20 µg/L), may in part, be attributable to direct or indirect effects of toxic concentrations of copper, but more study at higher pH and higher hardness levels are required to support this hypothesis. Reduced growth rate of *Lithobates pipiens* (Schreber) tadpoles (Lande and Guttman 1973) and reduced antipredator response by *Rana luteiventris* Thompson tadpoles (Lefcort et al. 1998) subjected to sublethal concentrations of metals have been reported. Similarly, Freda and Dunson (1985) have pointed out that reduced growth rate resulting from low pH can cause gape-limited predators such as *Ambystoma* larvae to be restricted to smaller prey because prey outgrow the size limitations of the predator. Reduced activity levels may contribute to reduced foraging efficiency and reduced growth rate of *Ambystoma* larvae which would extend the larval time to transformation and require a lengthened hydroperiod.

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The Aquatic Animal Community in a Chagrin River Tributary at Case Western Reserve University's Squire Valleevue Farm

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Abstract: Since 1937 Case Western Reserve University has been managing Squire Valleevue Farm as a natural resource for education, research, and recreation. One of the most notable natural features of the property is a small headwater tributary of the Chagrin River that runs from west to east across the Farm's property. Even though the stream is a valuable educational resource, and its location at the Farm affords it a degree of environmental protection, the aquatic animal community inhabiting the stream remains undocumented. Therefore, the stream's fish, amphibian, and macroinvertebrate species were surveyed to determine which species are present. In addition, the typical ecological characteristics of each fish species were analyzed and compared to their geographical distributions within the stream in order to determine their path of immigration into the stream. Stream-adapted species (Western Blacknose Dace, *Rhinichthys obtusus*; Creek Chub, *Semotilus atromaculatus*) were found at downstream sites close to the Chagrin River, suggesting that these species had naturally colonized upstream from the River. Several pond-adapted species (Bluegill, *Lepomis macrochirus*, Largemouth Bass, *Micropterus salmoides*, Yellow Bullhead, *Ameiurus natalis*) were found at upstream sites that would be difficult to reach through natural colonization due to the presence of large waterfalls. The geographical distribution of these species within the stream indicates that at most two of them may have immigrated from artificial ponds located on Farm property, but at least two of the three species immigrated from a source located upstream of Farm property. The pond-adapted fishes are relatively large, predatory species, and their effects on the amphibian and macroinvertebrate communities remain to be determined.

Key Words: amphibian, exotic, fish, Great Lakes, invertebrate, Lake Erie, native, non-native, stream

Introduction

Squire Valleevue Farm, located in Hunting Valley, Ohio, was a gift to Case Western Reserve University in 1937 by the late Andrew Squire (Locci and Bond 2011). Since then, the 277 acres of the Farm have served the overall University community by providing opportunities for research, recreation, and education. The Farm also functions essentially as a nature preserve, because its property is protected from human development. A small stream runs from west to east along the northern border of the Farm's property and empties into the Chagrin River, which flows from south to north just east of the Farm and empties into Lake Erie. The stream is typically between approximately 1 and 2 m wide, and is typically only a few cm deep although it may be deeper (approximately 0.5 m) in pools. This stream is one of the most interesting natural features of the Farm, but the fish, amphibian, and macroinvertebrate species inhabiting the stream have not previously been documented. The goal of the current study was to survey the aquatic community living in the stream.

The presence of any native fish species in the stream would most likely be due to migration upstream from the Chagrin River. Over the past 3 million years, continental ice sheets have repeatedly advanced and retreated over the Great Lakes drainage (Smith et al. 2004). Species currently native to the Chagrin River and its tributaries originally colonized the area after the last glacial period, the Wisconsinan glaciation, retreated over 14,000 years ago (Ehlers and Gibbard 2004). At that time, ice-marginal lakes formed over the area that now encompasses the Great Lakes. Cool-water fishes colonized Lake Erie via inlets from several directions; the Wabash River connected Lake Maumee, Lake Whittlesey, and Lake Warren to western Lake Erie while the Hudson River connected Lake Wayne and Lake Warren to present day East Lake Erie (Smith et al. 2004; Szabo and Chanda 2004). Warm-water fishes entered Lake Erie mainly from the Ohio River drainage as numerous headwaters of southern tributaries to Lake Erie eroded headward, capturing headwater neighbors to the south as they did so (Smith et al. 2004). As glaciers receded after the Wisconsinan glaciation, the Chagrin River cut through the Allegheny Plateau towards Lake Erie (White 1982). However, the flow of the Farm stream is currently interrupted by numerous waterfalls that would impede fish migration upstream from the Chagrin River. Two of these barriers are exceptionally large. The waterfall closest to the Chagrin

River is currently in the form of a particularly large (approximately 4 m tall) man-made concrete wall. The second large waterfall is located further upstream and is much larger (approximately 10 m). If fishes were to be found in the stream, it would be expected that they would be small stream-adapted species that colonized upstream from the Chagrin River over the past 14,000 years, and more species would be expected at sites closer to the Chagrin River.

An alternative pathway for colonization could be from artificial ponds both on and nearby the Farm property. There are several ponds at the Farm that, after heavy rains, drain into the stream via two small intermittent drainage ditches. Both Bluegill, *Lepomis macrochirus* (Centrarchidae), and Largemouth Bass, *Micropterus salmoides* (Centrarchidae), are known to inhabit these ponds at high densities. There are also several ponds located off of the Farm property that could be potential routes of colonization. By comparing the geographical distributions of the fishes in the stream with their known ecological characteristics, we determine the most likely source of each species.

Fishes observed in the stream might function as consumers of invertebrates and small amphibians, in addition to macrophytes, phytoplankton, and other smaller fishes. The macroinvertebrates and amphibians in the stream were also sampled.

Methods

Study Site

Squire Valleevue Farm is located 14.5 kilometers east of Cleveland at 37125 Fairmount Boulevard, Chagrin Falls, OH 44022. Originating off the property, the stream enters the Farm at its northern border at Cedar Road and flows east into the Chagrin River. During its entire length within Farm property, the stream is surrounded by wooded terrestrial habitat. Two intermittent ditches allow the Farm's man-made ponds to drain into the stream during heavy rains. The ponds are known to contain Bluegill (*Lepomis macrochirus*) and Largemouth Bass (*Micropterus salmoides*). The section of stream upstream from where the west ditch intersects has low gradient with mostly muddy substrate. The section downstream of the west ditch has a steeper gradient, is characterized by a series of waterfalls, has a rockier substrate consisting of bedrock, cobble, and gravel, and is in a gorge surrounded by steep, high walls. Because of the physical differences between the two sections, samples taken upstream of where the west ditch intersects the stream were categorized as "upstream" samples and designated with negative numbers (-1 through -3), and those taken downstream of where the ditch intersects the stream were characterized as "downstream" samples, and were designated with positive numbers (1 through 6). Therefore, there were three sample sites upstream and six downstream, for a total of nine sample sites (Figure 1).

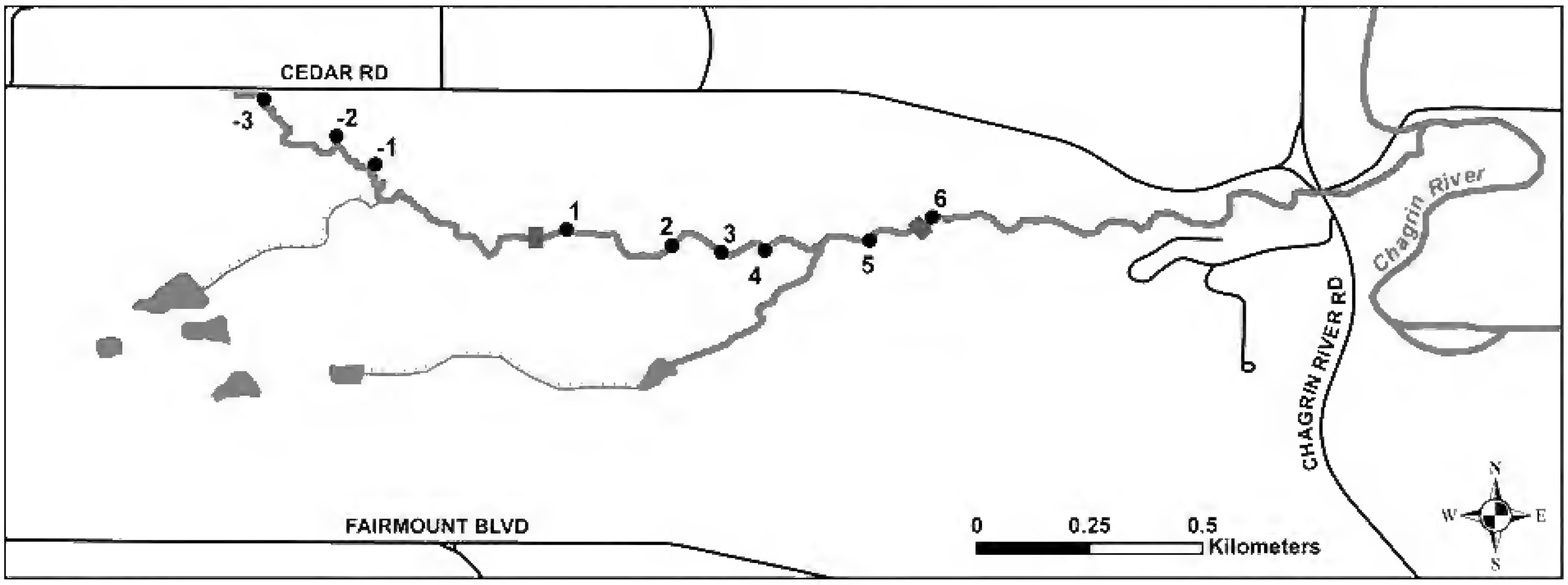

Figure 1. The nine study sites at Squire Valleevue Farm. Beginning north of the property, the stream enters the Farm at Cedar Road, flows downstream from west to east, and ends in the Chagrin River. Several research ponds at the Farm drain into the stream during heavy rainfall via two small ditches (hatched lines). Samples taken downstream of where the west drainage ditch intersects the stream are categorized based on physical differences (see text) as "downstream" samples (positive numbers) and those taken upstream of where the west ditch intersects the stream are characterized as "upstream" samples (negative numbers). Two exceptionally large waterfalls (see text) are indicated by brown rectangles.

Fishes

Fishes were sampled on several dates in the spring and fall, beginning in fall 2008 and ending in spring 2011. Fishes were sampled with either a 6 ft. or 12 ft. seine, depending on the width and depth of the stream at a specific sample site. On the first sampling date, 2 September 2008, fishes were permanently removed from the stream because of their presumably non-native status and to observe their potential re-immigration into the stream. Otherwise, fishes were captured, photographed, identified, and then released back into the stream. In two cases fishes were observed visually from the bank and were confidently identified without capture. Due to their presumably small populations, voucher specimens were not collected and archived. At each site, seine hauls were performed until no new species were obtained.

Amphibians

Amphibians were observed on several occasions throughout the stream and were intentionally sampled on 28 September 2010 at site 1 by looking under moist rocks within 2 m of each edge of the stream. Salamanders were identified and then each rock was slowly lowered back down in its original position. Amphibians were also sampled incidentally with a seine during fish sampling at all nine sample sites. Funnel traps were deployed upstream at sites -1 and -2, and downstream at sites 3 and 4 from 27 October 2010 – 28 October 2010 (See Macroinvertebrates sub-section below). Amphibians were identified with an ODNR field guide or photographed for future identification (ODNR 2008; Bartlett and Bartlett 2006). Due to their presumed small populations, voucher specimens were not collected and archived.

Macroinvertebrates

Macroinvertebrates were sampled upstream and downstream sites. They were also recorded if captured incidentally while seining fishes at other sites. Three main methods were used to sample macroinvertebrates in the stream; dip netting (D-frame and circular), funnel traps, and Hester-Dendy artificial substrate traps. For all three of these methods, invertebrates were preserved in 95% ethanol and vouchered at the Cleveland Museum of Natural History (catalog numbers pending). To get a general understanding of macroinvertebrate diversity in the stream, specimens were identified to the taxonomic level of family (Packarsky 1990; Thorp and Covich 2009).

The D-frame dip net was used on 17 October 2010 at sites -1 and -2 and at sites 3 and 4, and on 20 March 2011 at downstream sites 3 and 4. Dimensions of the D-shaped frame were 30 cm width x 30 cm height, and the netting had a standard mesh size of 500 microns. The circular dip nets had a 30 cm diameter. Nets were used in a variety of habitat types as kick nets or swept across the substrate. Dip net sampling continued at each downstream and upstream site until repetitive sampling produced no new taxa.

Funnel traps were constructed out of aluminum window screen. The cylinder was 45.7 cm long and 20.3 cm in diameter. The two funnel ends began 20.3 cm in diameter and tapered inward 12.7 cm to a 4.4 cm opening. A string handle running from end to end was attached to the two seams where the cylinder and funnels ends joined. The funnel traps were set on the substrate at a location deep enough to submerge them. Funnel traps were left for 24 hours from 27 October 2010 – 28 October 2010 at sites -1 and -2 and at sites 3 and 4 to capture macroinvertebrates with diurnal and nocturnal activity patterns (Ohio EPA 2004).

Hester-Dendy (HD) artificial substrate samplers were placed at each of four sites: -1, -2, 1, and 2. They were tied to metal weights with 20 – 40 cm of string. The samplers were left submerged in the stream for a period of three weeks, from 27 October 2010 – 17 November 2010. The synthetic substrate plates allowed the sampling of organisms which are slow to colonize, such as caddisflies.

Results

Fishes

Since the fall of 2008 five different fish species have been found in the Farm stream (Figure 2). Overall, stream-adapted cyprinid species, Creek Chub (*Semotilus atromaculatus*) and Western Blacknose Dace (*Rhinichthys obtusus*), were found at sample sites closer to the Chagrin River, and pond-adapted species, Yellow Bullhead (*Ameiurus natalis*, Ictaluridae), Bluegill, and Largemouth Bass, were found at sample sites farther away from the Chagrin River (Table 1).

Amphibians

Nine amphibian species were found in the Farm stream (Table 2). None were caught in the funnel traps and some were caught in seine hauls. Most were observed under rocks. A large number of salamanders (Plethodontidae),

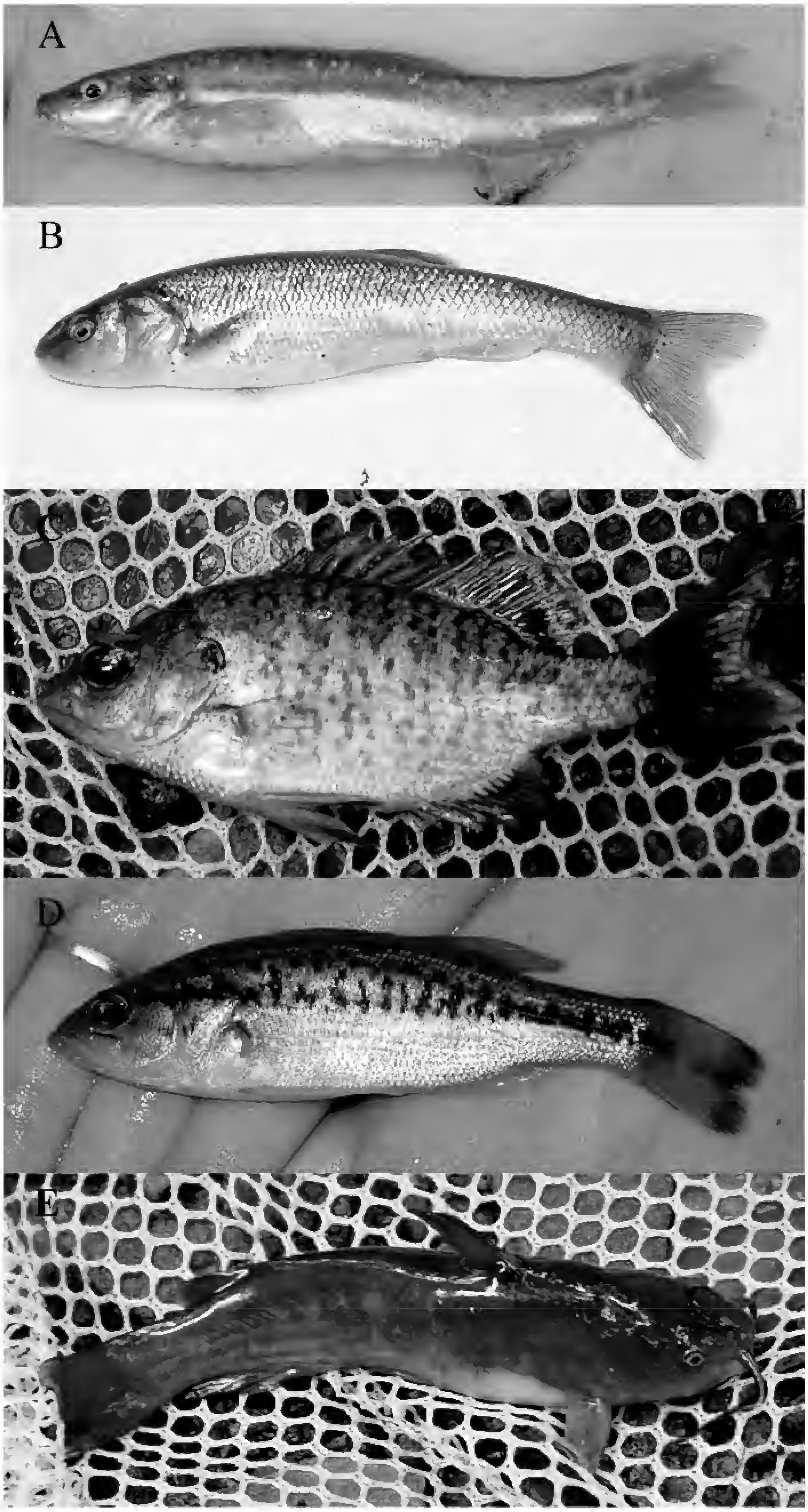

Figure 2. Photographs of fishes captured in the stream at Squire Valleevue Farm. (A) Western Blacknose Dace (*Rhinichthys obtusus*), (B) Creek Chub (*Semotilus atromaculatus*), (C) Bluegill Sunfish (*Lepomis macrochirus*), (D) Largemouth Bass (*Micropterus salmoides*), (E) Yellow Bullhead (*Ameiurus natalis*).

including the Northern Dusky Salamander (*Desmognathus fuscus*), the Mountain Dusky Salamander (*Desmognathus ochrophaeus*), the Northern Two-Lined Salamander (*Eurycea bislineata*), the Redback Salamander *(Plethodon cinereus*), and the Northern Red Salamander (*Pseudotriton ruber ruber*) were observed. Frogs observed include the Northern Spring Peeper (*Pseudacris crucifer crucifer,* Hylidae), Green Frog tadpoles and adults (*Lithobates clamitans melanota,* Ranidae), the Pickerel Frog (*Lithobates palustris,*Ranidae), and the Bullfrog tadpole (*Lithobates catesbeianus*, Ranidae).

Macroinvertebrates
A total of 16 different families of macroinvertebrates were observed in the stream. No macroinvertebrates were caught in the funnel traps. Most were caught with dip nets and the Hester-Dendy artificial substrate traps. Fifteen families were present in the fall, but only eight families were present in the spring (Tables 3, 4). Four of these taxa

Table 1. Fishes collected from the stream at Squire Valleevue Farm from 2 September 2008 to 20 March 2011. For sampling location, the higher the number assigned to the sampling site, the closer it is to the Chagrin River. Sample site -3 was the farthest upstream site, where the stream first enters Farm property at Cedar Road. Sample site 6 was the farthest downstream site.

Sample Site	Latitude	Longitude	Date	Bluegill	Yellow Bullhead	Largemouth Bass	Creek Chub	Blacknose Dace
-3	41.50054	-81.42494	9/25/2010	4	0	0	0	0
-2	41.49980	-81.42350	9/25/2010	3	1	0	0	0
-1	41.49881	-81.42221	9/25/2010	0	0	0	0	0
1	41.49794	-81.41891	9/2/2008	70	1	0	0	0
			4/24/2009	1	0	0	0	0
			3/20/2010	0	0	0	0	0
			9/4/2010	6	1	0	0	0
			3/20/2011	0	0	0	0	0
2	41.49762	-81.41680	9/4/2010	1	0	0	0	0
3	41.49748	-81.41582	9/4/2010	1	0	0	0	0
4	41.49752	-81.41496	8/11/2009	2	0	0	0	0
			9/4/2010	0	0	0	0	0
5	41.49772	-81.41286	9/4/2010	2	0	1	0	0
6	41.49819	-81.41161	3/20/2010	0	0	0	2	3
			9/4/2010	2	0	0	9	11
			3/20/2011	0	0	0	3	0

Table 2. Amphibians found in the Farm stream and the date they were observed.

Common Name	Scientific Name	Date Observed
Northern Dusky Salamander	*Desmognathus fuscus*	3/20/2010, 9/28/2010
Mountain Dusky Salamander	*Desmognathus ochrophaeus*	9/28/2010
Northern Two-Lined Salamander	*Eurycea bislineata*	4/27/2008, 9/28/2010
Redback Salamander	*Plethodon cinereus*	9/4/2010, 9/28/2010
Northern Slimy Salamander	*Plethodon glutinosus*	8/8/1981*
Northern Red Salamander	*Pseudotriton ruber ruber*	9/18/2010
Pickerel Frog	*Lithobates palustris*	3/20/2010
Northern Spring Peeper	*Pseudacris crucifer*	9/28/2010
Green Frog	*Lithobates clamitans melanota*	9/25/2010
Bullfrog tadpole	*Lithobates catesbeianus*	9/25/2010

*record of this species comes from a specimen cataloged at the Cleveland Museum of Natural History were found in both the upstream and downstream regions of the Farm stream: one crustacean species of the genus *Gammarus*, one insect species of the family Simulidae, one insect species of the family Saldidae, and the leech *Erpobdella punctata* (Tables 3, 4). Downstream, where the sediment was rocky and the water moved more quickly, Trichoptera and Plecoptera larvae were found (Tables 3, 4). All taxa are vouchered at the Cleveland Museum of Natural History except the crayfish, *Cambarus* sp., which was captured while seining for fishes both on the invertebrate sampling dates and other dates and identified via photograph (Whitney G. Stocker pers. comm.). Anisoptera odonate larvae were also regularly captured incidentally while seining for fishes, but were not collected.

Discussion

Fishes

The ecological characteristics of each fish species and its geographical distribution within the stream indicate that there have been two sources for fish immigration into the stream. The two stream-adapted species, Creek Chub and

Table 3. Macroinvertebrates observed during the spring on 20 March 2011 at three downstream sites. Sites 3 and 4 were deliberately sampled using dipnets. Macroinvertebrates were identified to the family level and vouchered at the Cleveland Museum of Natural History, except for *Cambarus* sp., which was captured incidentally at site 6 while seining fishes and was not collected.

Class	Order	Family	Genus	Species	Site	n
Crustacea	Amphipoda	Gammaridae	*Gammarus*	sp.	3, 4	16
Crustacea	Decapoda	Cambaridae	*Cambarus*	sp.	6	1
Hirudinea	Arhynchobdellida	Erpobdellidae	*Erpobdella*	*punctata*	4	1
Insecta	Diptera	Chironomidae	*Chironomus*	*plumosus*	3, 4	6 (larvae)
Insecta	Diptera	Tipulidae	-------	-------	4	1 (larva)
Insecta	Hemiptera	Gerridae	*Gerris*	sp.	3, 4	1
Insecta	Plecoptera	Perlodidae	-------	-------	4	1
Insecta	Trichoptera	Hydropsychidae	*Cheumatopsyche*	sp.	3	1 (larva)

Table 4. Macroinvertebrates observed in the Farm stream during the fall on 17 October 2010 (dipnet) and 17 November 2010 (Hester-Dendy). Sites -1, -2, 3, and 4 were deliberately sampled. Macroinvertebrates were identified to the family level and vouchered at the Cleveland Museum of Natural History, except for *Cambarus* sp., which was captured incidentally at sites 5 and 6 while seining fishes and was not collected.

Class	Order	Family	Genus	Species	Site	n
Crustacea	Amphipoda	Gammaridae	*Gammarus*	sp.	-1, -2, 3, 4	102
Crustacea	Decapoda	Cambaridae	*Cambarus*	sp.	5, 6	2
Hirudinea	Arhynchobdellida	Erpobdellidae	*Erpobdella*	*punctata*	-1	1
Insecta	Coleoptera	Dystiscidae	*Copelatus*	sp.	-2	1 (larva)
Insecta	Diptera	Simulidae	----	----	-2, 3, 4	4 (larvae)
Insecta	Diptera	Tipulidae	----	----	3	1 (larva)
Insecta	Hemiptera	Saldidae	----	----	-1, -2, 3, 4	9
Insecta	Hemiptera	Gerridae	*Gerris*	sp.	3, 4	7
Insecta	Odonata	----	----	----	-2	1 (larva)
Insecta	Plecoptera	Perlordidae	----	----	4	1
Insecta	Trichoptera	Hydropsychidae	*Cheumatopsyche*	sp.	4	6
Insecta	Trichoptera	Philopotamidae	*Chimarra*	sp.	4	2
Gastropoda	Basommatophora	Physidae	*Physella*	*integra*	-1	1
Gastropoda	Basommatophora	Planorbidae	*Planorbella*	*trivolis*	3	1
Turbellaria	Tricladida	----	----	----	-1	2

Western Blacknose Dace, were only caught at site 6, the sample site furthest downstream (Figure 1, Table 1). These species are typically found in cool water and appear to have colonized naturally from the Chagrin River, but they were limited in their movement upstream by the large waterfall. Surprisingly, three pond-adapted species (Bluegill, Largemouth Bass, and Yellow Bullhead) were found at sites upstream of the first waterfall, which would be difficult to reach through natural immigration. These fishes appear to be immigrating into the stream from anthropogenic sources, possibly coming from outside the Farm.

Western Blacknose Dace were only caught at one site, site 6, which was characterized by a large pool just downstream of the large concrete wall, which formed a waterfall into the pool (Table 1). They apparently made their way into the stream by migrating upstream from the Chagrin River. Western Blacknose Dace are known to be a cool water stream-adapted species that typically inhabits moderate to high flow brooks with clear waters and permanent flow (Trautman 1957). They require sand or gravel bottoms with distinct riffles in order to spawn, and rely on deep pools, brush, and roots to provide shelter from predators. Since the early 1900s there have been large decreases in the abundance of Western Blacknose Dace as populations were eliminated due to habitat modification. During the housing boom beginning in 1925 many natural sand and gravel bottomed streams that were bordered by forest and brush were converted into turbid silty streams of intermittent flow (Trautman 1957). Like the Western Blacknose Dace, the Creek Chub is a cool water stream-adapted species (Trautman 1957). It is abundant throughout Ohio, living mostly in creek habitats in the spring and moving downstream into deeper waters after spawning. Most Creek Chub populations seek shelter in the deep pools of larger streams during times of little rainfall and in the winter months. As temperatures approach 5° C in the spring, they move into smaller streams or smaller portions of a stream. The preferred habitat of the Creek Chub closely mirrors that of the Western Blacknose Dace: well scoured bottoms of sand, gravel, boulders, and bedrock with distinct riffles and deep pools with places to hide (Trautman 1957). Migration of Western Blacknose Dace and Creek Chub upstream of site 6 may have historically been blocked by the presence of an impassible barrier that was at some point converted to the large concrete wall that exists there today. If there ever were any Western Blacknose Dace or Creek Chub located at sites upstream of site 6 then they were at one time extirpated but unable to re-colonize after the formation of the barrier. It seems unlikely that these species ever existed at the muddy upstream sites (sites -1 through -3) due to their known requirement for the type of rocky substrate and deep pools that characterize the downstream portion of stream.

The Bluegill appears not to be native to the Farm stream. Bluegill have existed in both the Ohio River and Lake Erie drainages since post-glacial times (Trautman 1957). Previous to 1900, Bluegill were present in kettle and oxbow lakes formed by glacial overflow throughout Ohio (Garlick 1857). Man-made canals greatly aided in the spread of Bluegill, and farm ponds and other small lakes were stocked with millions of them between the 1920s and the 1950s (Whittier et al. 1999). The heartiest Bluegill populations are in non-flowing waters that tend to be clearer with only slight suspended clay silts and organic debris (Mittelbach 1981). Non-flowing water bodies are able to sustain at least patchy macrophyte beds which allow juvenile sunfishes to forage and avoid predation from Largemouth Bass. When juveniles grow larger in the summer they move out of the vegetation and into the open water to feed on *Daphnia* (Mittelbach 1981). Considering the habitat type in which Bluegill are typically found, and that they were found at downstream sites 1, 2, 3, 5, 6, as well as at upstream sites -2, and -3, upstream of several large migration barriers, it seems unlikely that they immigrated into the stream naturally from the Chagrin River. The fact that they were found at site -3, where the stream enters Farm property, suggests that they are entering the stream from locations off the Farm property, as well as possibly through the drainage ditches from the ponds located on Farm property.

The Largemouth Bass is a pond-adapted species that is not typically found in streams such as the one at the Farm. It typically occurs in non-flowing waters including ponds, lakes, impoundments, oxbows, and overflow ponds, which are clear and support extensive aquatic vegetation (Smith et al. 2004; Trautman and Gartman 1974). Largemouth Bass prefer a substrate of silt, organic debris, sand, or clay rather than the rocky substrate at site 5 downstream where one was found (Table 1). Historical records of the Largemouth Bass indicate that it was present before 1900 in the shallow waters of Lake Erie, and in small glacial lakes (Garlick 1857, Trautman 1957). As early as 1830 the species gained commercial importance and many ponds and canals were stocked with Largemouth Bass (Klippart 1877). This species was found only at downstream site 5. Because the fish was found downstream rather than upstream, the Farm pond confluence cannot be ruled out as a source of colonization. Largemouth Bass could be migrating into the stream from artificial populations located off of Farm property or from the Farm ponds.

It also seems unlikely that the Yellow Bullhead is native to the Farm stream. The species is adapted to live in areas of high aquatic vegetation, usually in larger bodies of water (Smith et al. 2004). It is not typically found in small rocky streams, but may be able to succeed there in the absence of the Brown and Black Bullheads (Smith et al. 2004). Historically, the largest Yellow Bullhead populations have resided in the shallow portions of large bays, lakes, and ponds with clear water and abundant aquatic vegetation (Trautman and Gartman 1974). Between 1880 and 1900 the Yellow Bullhead was widely distributed throughout Ohio, more so in the Lake Erie drainage than in the Ohio River drainage (Trautman 1957). In the current study, it was found at the upstream site -2, and at one downstream site, site 1. Because the Yellow Bullhead was found so far upstream from the confluence with the Farm pond drainage ditch it seems likely that that species is colonizing from populations located off the Farm property. It is more likely that the fish swam downstream from property north of the Farm than swam all the way upstream from the confluence with the ditch. Moreover, there is no record of any catfish in the ponds located on Farm property.

The presence of Bluegill and Yellow Bullhead so far upstream indicates that at least these two species are colonizing from an artificial population located off of Farm property. The fact that only Bluegill and Largemouth Bass are known to occur in the ponds located on Farm property indicates that at most these two of the three pond-adapted species present in the stream may be colonizing from the artificial ponds on Farm property. After 1940, hundreds of farm ponds were dug across Ohio. The majority of these ponds were stocked with Largemouth Bass and Bluegill. Individuals that escaped during flooding seem to be responsible for the widespread distribution of these species throughout Ohio streams where they were absent before 1887 (Trautman and Gartman 1974).

Amphibians

Nine amphibian species were found to inhabit the stream at the Farm. Of note was the Northern Red Salamander, which had not previously been observed at the Farm, but whose identity was confirmed independently by T. Matson, M. Benard, and K. Krynak from a series of photographs. Additional species have been observed at the Farm, although they were not observed in the current study. The American Toad (*Anaxyrus americanus*; Bufonidae) has been observed by Dr. Carl Anthony and the Red-spotted Newt (*Notophthalmus viridescens*; Salamandridae) has been observed by Dr. Martin Rosenberg (Anthony CD, pers comm.; Rosenberg MJ, pers. comm.). The Northern Slimy Salamander, *Plethodon glutinosus* (Plethodontidae) was caught at the Farm in 1981 and vouchered at the Cleveland Museum of Natural History (No. 00002297). There is no reason to believe that any of the amphibian species observed are not native to the stream (Bartlett and Bartlett 2006).

Macroinvertebrates

A large number of invertebrates were collected from the stream. In the fall, a total of 15 different families were collected and in the spring eight families were collected. The difference in number of taxa collected between spring and fall is most likely due to differential sampling effort. Only sites 3 and 4 were used both in the spring and in the fall. In the spring, seven families were collected with dipnets from sites 3 and 4. In fall, nine families were collected with dipnets and Hester-Dendy samplers from the same sites. More EPT (Ephemeroptera, Plecoptera, and Trichoptera) taxa were collected in the downstream portion than in the upstream portion of the stream. In the fall, upstream and downstream sites were sampled equally, and three EPT families were found at the rocky downstream sample sites, and none were found at the muddy upstream sites. Many EPT taxa are pollution intolerant and are often used as bio-indicators of habitat quality (OEPA 1987; Thorp and Covich 2009). This work serves as an initial survey of macroinvertebrates in this stream, which will provide a basis for future, species-level work.

A crayfish, *Cambarus* sp., was seined several times at downstream sample sites. The Rusty Crayfish, *Orconectes rusticus*, a known invasive species throughout the Lake Erie watershed, was not found in the stream (Jezerinac 1982, Jezerinac and Thoma 1984). However, observations of crayfishes were limited to individuals captured incidentally while seining for fishes, and voucher specimens were not collected. A more detailed analysis of the crayfishes present in the stream involving thorough collection and lab-based identification is warranted. Introduction of the Rusty Crayfish in northern Ohio has resulted in the displacement of native crayfish species and decreased macroinvertebrate species diversity (Klocker and Strayer 2004). McCarthy et al. (2006) have shown negative correlations between Rusty Crayfish populations and the abundance of Diptera, Ephemeroptera, Odonata, Trichoptera, and total zoobenthos.

Conclusions

The Chagrin River tributary located at Squire Valleevue Farm hosts a limited number of native fishes, but larger numbers of amphibians and macroinvertebrates. Overall, it was determined that three of the five fish species found in the Farm stream were non-native to the environment, and that they were most likely immigrating from outside of Farm property. This is significant because these species, Bluegill, Yellow Bullhead, and Largemouth Bass, are large-growing predatory species and have the potential to negatively impact the stream's amphibian and macroinvertebrate communities. At this time it is not possible to determine the effect that the non-native fishes are having on the other organisms living in the stream. It is, however, possible that the effect is dampened by the seasonal pattern observed in the presence of the non-native fishes in the stream. In the spring when amphibian species are most active and susceptible to predation, the non-native fishes are found in very small numbers. By comparison, non-native fishes are found in the stream in much larger numbers during the fall. It is possible that by the time non-native fishes populate the stream in the fall, amphibians are less vulnerable to predation because they are not out in the open, breeding. Additional study is required to fully understand the interactions among the different species that occupy the stream. Nevertheless, it would seem prudent for future management decisions to consider options that would prevent the introduction of non-native species into the otherwise protected Farm stream in order to conserve the native aquatic biota found there.

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The Distribution of Aquatic Turtles along the Ohio, Great Kanawha, and Little Kanawha Rivers, West Virginia, with Emphasis on *Graptemys ouachitensis* and *G. geographica.*

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Abstract: Visual surveys were conducted to investigate the spatial distribution of the Northern Map Turtle (*Graptemys geographica*) and the Ouachita Map Turtle (*Graptemys o. ouachitensis*) in the Ohio, Great Kanawha, and Little Kanawha rivers, West Virginia, from May 24 to August 8, 2010. Both species were detected and photographed on the Ohio, Great Kanawha, and Little Kanawha rivers. Ouachita Map Turtles were documented in 3 new counties and Northern Map Turtles were documented in 2 new counties. Additionally, new county records were documented for Eastern Spiny Softshells (*Apalone s. spinifera*) and Eastern Musk Turtles (*Sternotherus odoratus*) and 42 photographs were deposited as vouchers at the West Virginia Biological Survey Museum. Further investigation is needed to determine the extent and continuity of Ouachita Map Turtle range in the Ohio River and its tributaries.

Key Words: *Graptemys ouachitensis*, *Graptemys geographica*, distribution, map turtle, basking

Introduction

Turtles are relatively understudied in West Virginia (Phu 2010). Map turtles in particular are not well known, yet they may be vulnerable to the pollution, siltation, habitat alteration, and power boating seen on West Virginia's rivers (Moll and Moll 2004; Bodie 2001; Vandewalle and Christiansen 1996). Two species of map turtles occur in West Virginia: the Northern Map Turtle (*Graptemys geographica*) that ranges from Arkansas north to Minnesota and east to southern Quebec; and the Ouachita Map Turtle (*G. o. ouachitensis*) that ranges from eastern Kansas, Arkansas, and East Texas east to Tennessee and north to southwest Wisconsin (Conant and Collins 1998; Ernst and Lovich 2009). In West Virginia, data on distribution and status of both species are limited (Green and Pauley 1987).

Herpetologists have assumed that the Ouachita Map Turtle occurs as a disjunct population in Ohio and West Virginia (Ernst and Lovich 2009, Green and Pauley 1987, Wynn and Moody 2006); however, the extent and viability of this population in West Virginia is not known. The Ouachita Map Turtle was first reported as part of West Virginia's herptofauna by Richmond in 1953 from three specimens collected in 1952 on the Little Kanawha River in Wirt County (CM 31245, 31246, 32063). In 1955, another specimen was collected from the same area (CM 34142). In 2000, Watson and Pauley (2006) captured a juvenile male in the lower Great Kanawha River in Mason County during a systematic trapping survey of the river's turtle assemblages. They did not know if these individuals were part of an established population, released pets, or wayward transients. Additional surveys throughout West Virginia in 2003 failed to detect any *Graptemys* species (Phu 2010). In the summer of 2009, we observed a female basking on the lower Kanawha River (Putnam County), providing further evidence for a population in West Virginia.

Much of the Ouachita Map Turtle's range overlaps with that of the Northern Map Turtle (Ernst and Lovich 2009); Fuselier and Edds (1994) often found the two species sympatrically in Kansas. Ouachita and Northern Map Turtles living sympatrically practice dietary and habitat partitioning (Fuselier and Edds 1994, Temple-Miller 2008, Vogt 1981). In West Virginia, Northern Map Turtles have been documented in more locations than Ouachita Map Turtles, although records for both species are few. Northern Map Turtles have been documented in Cabell, Lewis, Mason, Monongalia, Putnam Raleigh, Summers, and Wirt counties (Green and Pauley 1987, Watson and Pauley 2006) and directly adjacent Wood County in Marietta, Washington County, OH (Conant, 1938).

Map turtles are shy and difficult to capture (Green and Pauley 1987) but populations have been successfully detected using visual searches from boats (Temple-Miller 2008). Researchers have successfully used spotting scopes and binoculars to study basking turtles (Carriere et al. 2008, Lindeman 1997, Phu 2010) and map turtles in particular (Coleman and Gutberlet 2008, Lindeman 1998, 1999a, 1999b, 1998). We investigated the distribution of map turtles in West Virginia using similar methods.

Methods

To investigate the spatial distribution of map turtles in West Virginia we conducted visual surveys for basking turtles on the Little Kanawha, Kanawha, and Ohio rivers from May 24 to the August 8, 2010. On the Little Kanawha River, we surveyed from the mouth to Newark and from the Elizabeth Locks to Henderson Run. On the Great Kanawha River, we surveyed from the mouth to Charleston. On the Ohio River, we surveyed from the mouth of the Guyandotte River to Green Bottom Wildlife Management Area, Ravenswood to Letart, Belleville to the mouth of the Little Kanawha River, and St. Marys to Sistersville. We also surveyed from St. Marys to approximately 4.5 km up Middle Island Creek. We searched the rivers from a 14 ft johnboat during daylight hours with most surveys occurring between 1100 and 1700 hours. We used binoculars, spotting scopes, and cameras equipped with telephoto lenses to identify turtles. When possible, photographs were taken and deposited as vouchers at the West Virginia Biological Survey Museum at Marshall University in Huntington, WV. We used a Garmin Vista HCx GPS unit (Garmin Ltd., Olathe, Kansas, USA; map datum NAD 83) to record the location of basking turtles and noted the type of basking object. We attempted to capture basking turtles with dip nets when basking logs provided an angle of approach that hid us from view. Specimens we captured were measured, photographed, and promptly released. We distinguished Ouachita Map Turtles from Northern Map Turtles by the former's strong vertebral keels with prominent spines, white irises, and large postorbital marks (Ernst and Lovich 2009).

Results

We observed 24 Ouachita Map Turtles on the Great Kanawha River at 15 locations, 3 on the Ohio River at 2 locations, and 5 on the Little Kanawha at 4 locations (Fig. 1). All but 3 Ouachita Map Turtles were observed basking on partially submerged logs which were not attached to the bank above the surface (one was on a rock, one was floating beside a partially submerged log not attached to the bank, and one was on a partially submerged log attached to the shore above the surface; Fig. 2). We captured a single male on the Great Kanawha River (weight: 170g; carapace length: 125mm; carapace width: 91mm; plastron length: 106mm; plastron width: 53mm). We also observed 19 Northern Map Turtles on the Great Kanawha River at 4 locations, 13 on the Ohio River at 7 locations, and 5 on the Little Kanawha River at 4 locations (Fig. 3). One Northern Map turtle was observed swimming while the rest were observed basking on partially submerged logs; however, unlike the Ouachita Map Turtles, logs attached and unattached to the bank above the surface were used.

We observed 10 basking map turtles that we were able to identify only to genus and 50 turtles that we were able to identify only as emydids before they dropped into the water. Additionally we observed 72 softshell turtles (*Apalone* sp.) including 11 identified to species (*A. s. spinifera*; Eastern Spiny Softshell) as well as three Red-eared Sliders (*Trachemys scripta elegans*), three Midland Painted Turtles (*Chrysemys picta marginata*), four Eastern Snapping Turtles (*Chelydra s. serpentina*), and three Eastern Musk Turtles (*Sternotherus odoratus*; Fig. 4). Our identification rate of emydid turtles was 63% to genus and 55% to species. We deposited 42 photographs as vouchers at the West Virginia Biological Survey Museum (Table 1).

On June 25, we observed evidence of softshell turtle nesting activity on sand banks along the Great Kanawha River. We saw numerous softshell tracks leading from the river to holes dug in the bank and back to the water. We also saw numerous depredated turtle nests in the lower sandy portions of the riverbank and in the higher areas consisting of decomposed organic debris. Additionally, we noticed many Muskrat (*Ondatra zibethica*) tracks that led from the river to a series of shallow holes dug throughout the nesting area. We had not seen Muskrat activity on previous visits to these sandy areas.

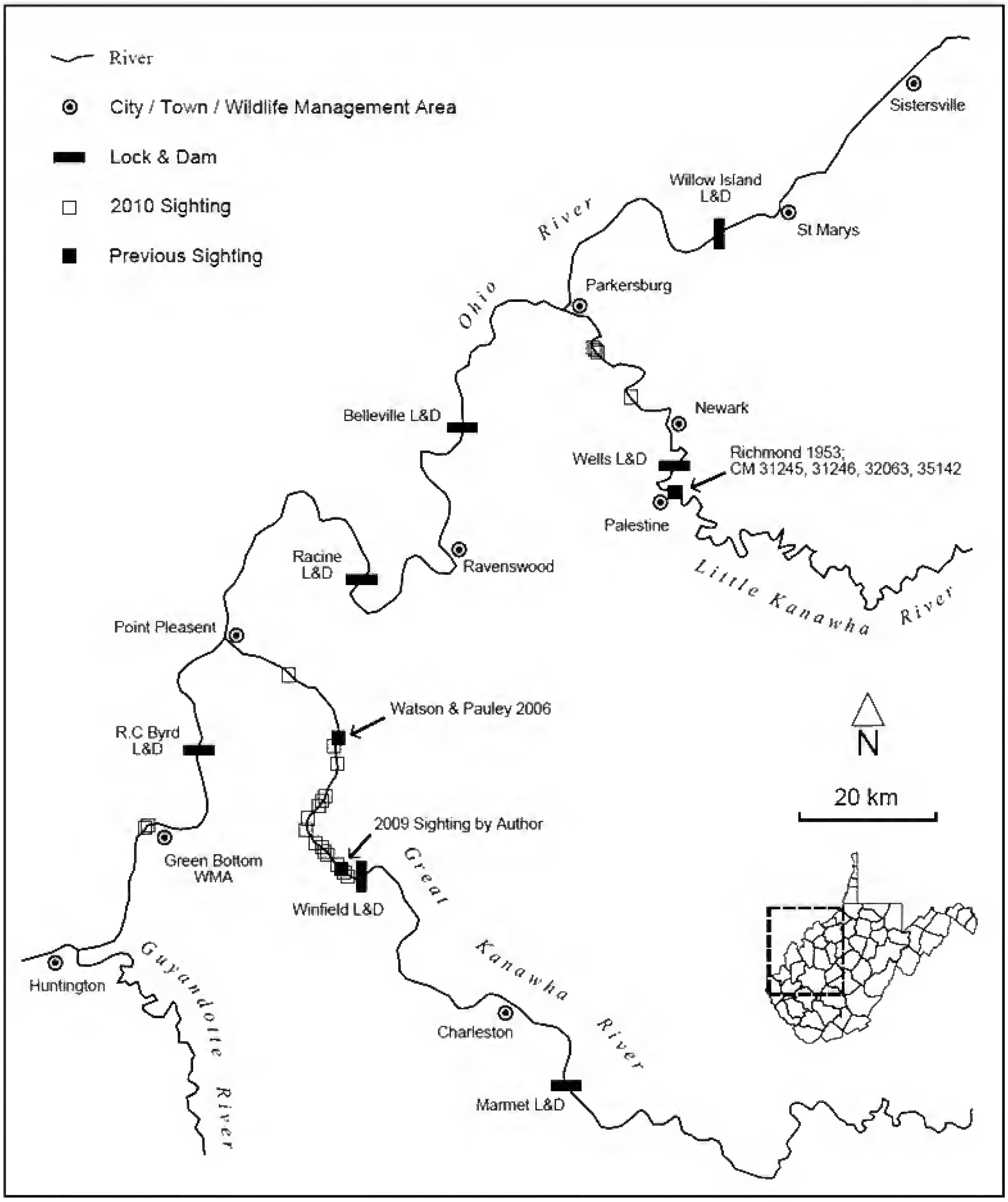

Figure 1. Ouachita Map Turtle (*Graptemys ouachitensis*) distribution along the Ohio, Great Kanawha, and Little Kanawha rivers, WV, from a 2010 visual survey and previous sightings/ records.

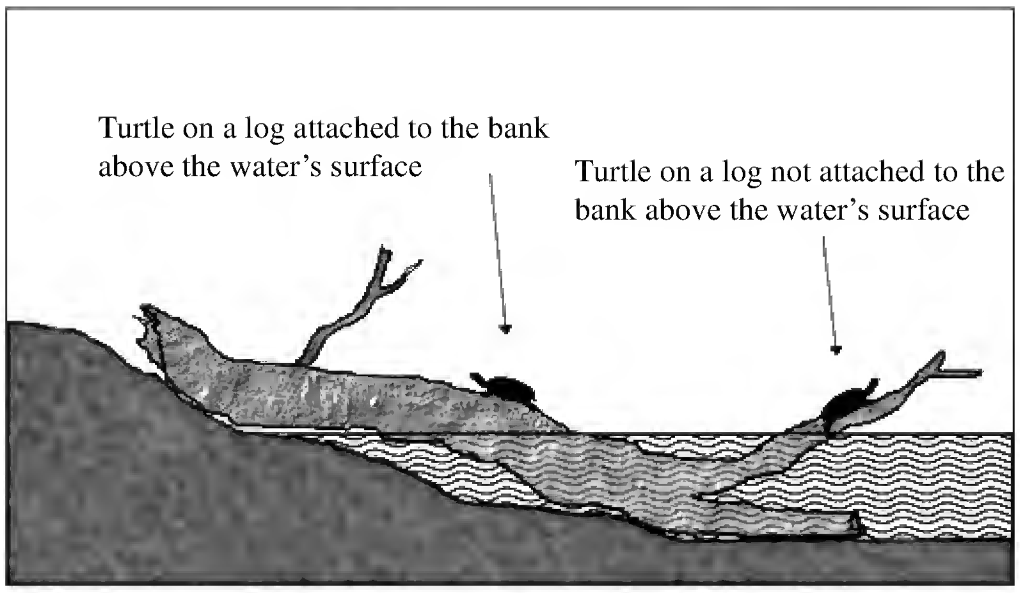

Figure 2. Turtles basking on a partially submerged log with positions attached and not attached to the bank above the water's surface.

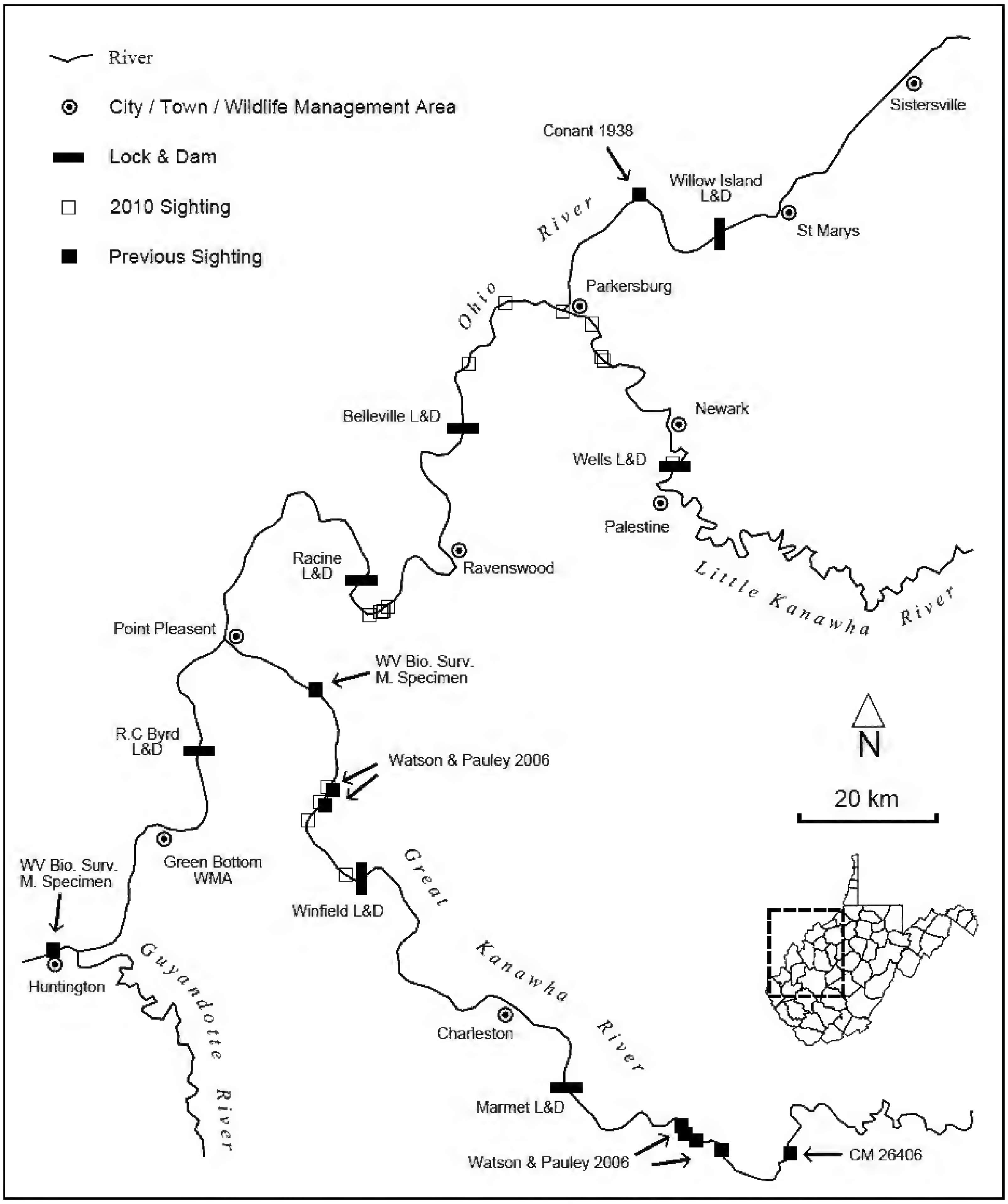

Figure 3. Northern Map Turtle (*Graptemys geographica*) distribution along the Ohio, Great Kanawha, and Little Kanawha rivers, WV, from a 2010 visual survey and previous records

Discussion

Ouachita Map Turtles and Northern Map Turtles were the most commonly encountered basking turtles along with softshell turtles during the course of our study. Watson and Pauley (2006) captured a single Ouachita Map Turtle after trapping the Great Kanawha River mainstem as well as its embayments and tributaries extensively. Their trapping efforts did yield numerous Midland Painted Turtles, Red-eared Sliders, Eastern Snapping Turtles, and Eastern Musk Turtles. Visual searches for basking turtles may represent a faster and more efficient method for detecting populations of map turtles on rivers compared to trapping, but a less productive method for other species. However, we likely would have observed these other species in abundance had we concentrated our efforts on backwaters and tributaries rather than river mainstems.

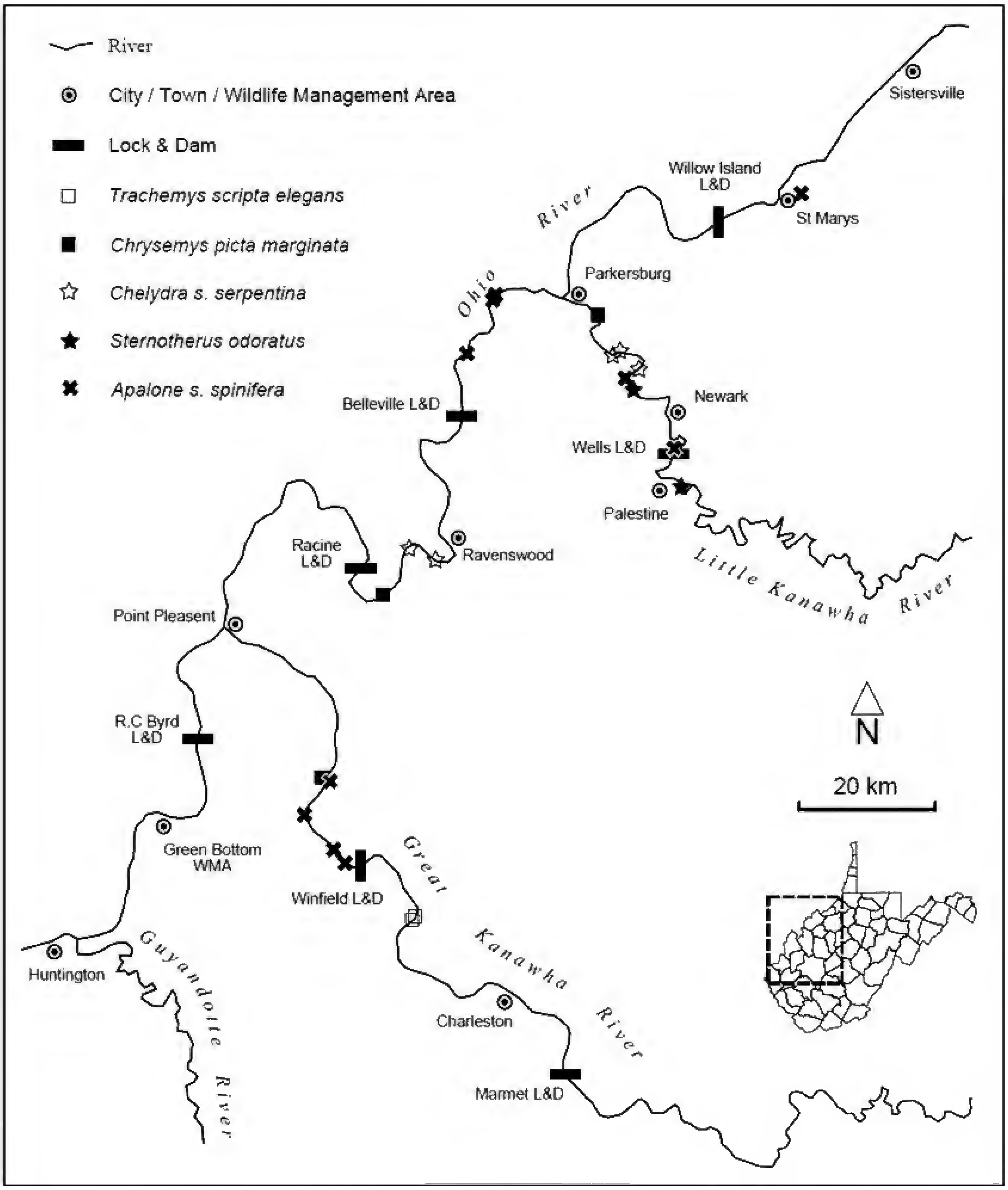

Figure 4. Red-eared Slider (*Trachemys scripta elegans*), Midland Painted Turtle (*Chrysemys picta marginata*), Eastern Snapping Turtle (*Chelydra s. serpentina*), Eastern Musk Turtle (*Sternotherus odoratus*), and Eastern Spiny Softshell (*Apalone s. spinifera*) sightings along the Ohio, Great Kanawha, and Little Kanawha rivers, WV, from a 2010 visual survey.

Our identification rate to species was less than we desired but similar to that of Temple-Miller (2008) on the lower Scioto River, Ohio. These low identification rates were likely due to the shy nature of map turtles and their willingness to rapidly abandon basking platforms upon approach of a boat. Red-eared Sliders and Midland Painted Turtles were more reluctant to retreat into the water. We thus expect that many of the emydid turtles that we were unable to identify to species were map turtles.

We observed fewer basking turtles on the Ohio River, which had higher recreational powerboat traffic during surveys, and fewer partially submerged logs than the Great Kanawha and Little Kanawha rivers. The Ohio River, unlike the other two rivers, also contained extensive emergent vegetation mats. Map turtles use emergent vegetation mats for aquatic basking (Bulté et al. 2010, Peterman and Ryan 2009) and would be more difficult to detect than

Table 1. Voucher photographs of turtles from a 2010 survey of the Ohio, Great Kanawha, and Little Kanawha rivers, WV, deposited in the West Virginia Biological Survey Museum at Marshall University, Huntington, WV. '*' indicates a new county record.

Graptemys ouachitensis		
Catalog #	Coordinates	County
WVBS 14902	N38.57277 W81.98867	Putnam*
WVBS 14903	N38.56621 W81.97828	Putnam
WVBS 14904	N38.53466 W81.94032	Putnam
WVBS 14905	N38.53490 W81.94047	Putnam
WVBS 14906	N38.56232 W81.97601	Putnam
WVBS 14907	N38.62055 W81.98312	Putnam
WVBS 14908	N38.63324 W81.97301	Putnam
WVBS 14909	N38.53814 W81.94611	Putnam
WVBS 14910	N38.60351 W82.00227	Putnam
WVBS 14911	N39.21316 W81.51927	Wood*
WVBS 14912	N39.21238 W81.51881	Wood
WVBS 14913	N39.21141 W81.51894	Wood
WVBS 14914	N39.15269 W81.45957	Wood
WVBS 14915	N38.59030 W82.27246	Cabell*
WVBS 14916	N38.59237 W82.26979	Cabell

Graptemys geographica		
Catalog #	Coordinates	County
WVBS 14917	N38.62609 W81.97785	Putnam
WVBS 14918	N38.53399 W81.93864	Putnam
WVBS 14919	N38.53448 W81.94000	Putnam
WVBS 14920	N38.60545 W82.00081	Putnam
WVBS 14921	N38.53468 W81.94002	Putnam
WVBS 14922	N38.62608 W81.97797	Putnam
WVBS 14923	N39.06789 W81.38890	Wirt
WVBS 14924	N39.20560 W81.50960	Wood
WVBS 14925	N39.24982 W81.52502	Wood
WVBS 14926	N38.88089 W81.86922	Jackson*
WVBS 14927	N38.87208 W81.89856	Jackson
WVBS 14928	N39.19786 W81.73187	Wood*
WVBS 14929	N39.27642 W81.66994	Wood

Apalone s. spinifera		
Catalog #	Coordinates	County
WVBS 14930	N38.53128 W81.93716	Putnam
WVBS 14931	N38.54915 W81.95891	Putnam
WVBS 14932	N38.58862 W82.00375	Putnam
WVBS 14922	N38.62608 W81.97797	Putnam
WVBS 14933	N39.06789 W81.38890	Wirt
WVBS 14934	N39.16029 W81.46376	Wood*
WVBS 14935	N39.40030 W81.16493	Pleasants*
WVBS 14936	N39.19351 W81.73373	Wood
WVBS 14937	N39.26656 W81.69006	Wood

Chelydra serpentina		
Catalog #	Coordinates	County
WVBS 14938	N39.19173 W81.48820	Wood
WVBS 14939	N39.19522 W81.48004	Wood
WVBS 14940	N38.92377 W81.78522	Jackson
WVBS 14941	N38.94331 W81.82642	Jackson

Chrysemys picta marginata		
Catalog #	Coordinates	County
WVBS 14942	N39.23991 W81.51643	Wood

Sternotherus odoratus		
Catalog #	Coordinates	County
WVBS 14943	N39.21451 W81.52122	Wood*

turtles basking on partially submerged logs. Map turtle populations on the Ohio River could also be reduced due to the detrimental effects of powerboat traffic (Bulté et al. 2010) and lower deadwood density (Lindeman 1999b). Only a single map turtle was observed basking on a rock; all other basking map turtles were observed using partially-submerged logs. Northern Map Turtles in an urban Indiana canal were found to use rock substrate for basking more frequently than deadwood (Peterman and Ryan 2009); however, Lindeman (1999b) concluded that deadwood is needed to support large populations of map turtles. The apparent unwillingness of Ouachita Map Turtles to use partially submerged logs which are attached to the bank above the surface could be a result of habitat partitioning or a strategy to avoid terrestrial predators. This behavior requires further investigation to determine if basking log position is important when managing habitat for Ouachita Map Turtles.

We suspect that the Muskrat digging activity in the softshell nesting areas was an attempt to locate turtle eggs. If so, this represents the first evidence for Muskrats as turtle nest predators, although Muskrat predation on juvenile softshell turtles was documented by Parmalee (1989). Muskrats are primarily vegetarians but also incorporate a wide variety of animal matter into their diets including mussels and clams (Kurta, 1995; Schwartz and Schwartz, 2001). It is not unreasonable that a mammal which digs up mussels would also opportunistically depredate turtle nests.

Our results confirmed the presence of Ouachita Map Turtle populations on the lower Kanawha River and their continued presence on the lower Little Kanawha River. We also expanded the known range of Ouachita Map

Turtles (with new county records in Cabell, Putnam, and Wood counties) and Northern Map Turtles (with new county records in Jackson and Wood counties) in West Virginia. Additionally we recorded new county records for Eastern Spiny Softshells (Wood and Pleasants counties) and Eastern Musk Turtles (Wood County). The presence of Ouachita Map Turtles on the Ohio River leads us to speculate that the West Virginia population is connected to western populations on the Ohio River and not disjunct as originally thought (Ernst and Lovich 2009, Green and Pauley 1987, Wynn and Moody 2006). Smith (2008) provided genetic evidence that Ouachita Map Turtles dispersed to the Ohio-West Virginia portion of their range following Pleistocene glaciations and do not differ genetically from those in the main portion of their range. Additionally Smith noted a report of Ouachita Map Turtles along the Ohio River in Pittsburgh, PA and suggested that the species may have a continuous distribution along the Ohio River. We suggest future investigations to determine the extent of Ouachita Map Turtle range on the Ohio River and its tributaries and whether the Ohio-West Virginia populations are truly disjunct. Also, the size and viability of Ouachita Map Turtle populations in West Virginia are not known and should be studied to determine if conservation efforts are needed.

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